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Fertility, Education, and Market Failures *

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Abstract:

We show that coordination failures may be part of an explanation for the demographic differences between rich and poor countries and their differing attitudes towards the use of child labor. Our analysis is carried out within a two-period, general equilibrium model with endogenous fertility, parental investment in children's education and firms' tradeoff between traditional technologies and the adoption of skill-intensive, modern ones. The model exhibits multiple equilibria due to the lack of a coordination mechanism between parental decisions on the quantity and the quality of children and entrepreneurs' technology choices.

Keywords:

Endogenous fertility, education, child labor, skill-biased technology, welfare, multiple equilibria, coordination

JEL classification: I20, J13, O33, J20

1 Introduction

In this paper, we show that a simple theory of coordination failures performs really well at explaining key stylized facts about Africa: its high fertility rate, its lack of investment in skill-biased technologies, the relatively low level of educational attainment within its population and the importance of its market for child labor.

African development is a euphemism for underdevelopment. According to the African Development Report (1998) published by the African Development Bank, overall economic performance remains vulnerable to adverse external shocks, unfavorable weather conditions, and societal conflicts.¹ On average over the last two decades, few African countries had positive real per capita income growth. Those that did, had growth rates much lower than would be expected from countries at the dawn of an industrial revolution. This lack of development remains one of the most puzzling issues for economic researchers and policy makers.

The accumulation of human capital in Africa is far behind that of industrialized countries, and the gap does not seem to close. In 1980 the mean years of schooling among individuals ages 25 and up was 1.5 in Sub-Saharan Africa, compared to 9.1 in industrialized countries. In 1990, these figures were, respectively, 1.6 and 10 (UNDP annual report, 1991, 1992, 1993).

Meanwhile, child labor is a mass phenomenon in Africa. The proportion of children ages 10-14 involved in any form of paid work lies between 20 and 30% (ILO, 1996; Canagarajah and Coulombe, 1997; Grootaert, 1998; Coulombe, 2001). If household chores were included in the definition of child labor, the above proportion would neighbor 100%.

Coincidentally, according to the World Bank (1999/2000), during the period 1980-1990, average annual growth of industrial value added was a dismal 0.9% in Sub-Saharan Africa, compared to 9.5% in East Asia and the Pacific for the same period, suggesting a serious lack of technological change in the former.

Africa also stands out for its average fertility rate in the neighborhood of 5 children per woman, compared to less than 2 for industrialized countries, and roughly 3 for South Asia (United Nations,

¹Pallage & Robe (2002) estimate the welfare costs of aggregate fluctuations in Africa to be at least an order of magnitude higher than similar estimates for the United States, regardless of the model economy in which the estimation is carried out.

social indicators).

We show that all these stylized facts can be reconciled within a simple theory of market failure. The absence of explicit coordination mechanisms between the fertility decisions of parents and their choice of education for their children on the one hand, and the decision by entrepreneurs to invest in skill-biased technologies on the other hand, generates multiple Nash equilibria, exhibiting the respective characteristics of rich and poor countries.

The analysis is carried out within a simple general equilibrium model with endogenous fertility, human capital accumulation and technology adoption. At the beginning of time, there are uneducated adults providing labor to entrepreneurs operating a traditional technology. The status quo can be carried over to the next period at no cost for anyone. An economic boom, however is possible in the future but requires today coordinated actions by all decision makers: it implies that firms invest in advanced technology whose operation will require skilled labor; it implies also, that parents make education decisions for their children consistently. Both types of investments (education and modern technology adoption) are risky: they entail a cost for parents and entrepreneurs respectively, but will only bear positive returns if made simultaneously. There lies the potential coordination problem we will analyze in the present paper.

Child labor is an ancient phenomenon. It goes back to the origins of mankind. Yet only recently did it become a cause of public outcry. Banning child labor has been considered an issue at most since the end of the industrial revolution in Europe and North America. The first international treaty on child labor was written in 1930 under the auspices of what became the International Labor Organization (ILO) in Geneva (Convention C29). Several other conventions have been designed since then. One of them, written in 1973, aimed at a complete eradication of child labor (ILO Convention C135), but failed to alter significantly the number of child laborers worldwide. The latest treaty, dated 1999, targets only the worst forms of child labor (ILO Convention C182). The fact and the matter are that no form of child labor is easy to eliminate using legislative intervention. The causes of child labor are multiple, but poverty is often a major reason why parents send their children to work (Anker, 2000). If child labor is merely a symptom of poverty, one had better ban poverty than child labor (Ranjan, 1999 and 2001; Dessy and Pallage, 2001b).

This paper combines three strands of literature: the literature on child labor, the literature on technology adoption and the literature on endogenous fertility. Understanding child labor has

stimulated much research in recent years (see, Basu, 1999, for a survey). Basu & Van (1998) show that multiple labor market equilibria can arise in a simple world in which adults and children are substitutable inputs in production. Banning child labor in this context, by pushing the economy in an equilibrium with higher wages, may have a positive effect on the welfare of families. Although intuitive, raising the minimum wage could have adverse effects on the number of child laborers, as was pointed out by Basu (2000). Baland & Robinson (2000) highlight the time inconsistency in children's promise to support their old age parents in the future as a possible cause of child labor. Dessy & Pallage (2001a) show that coordination failures may have a role in explaining why relatively well-off, altruistic parents may choose work over education for their children. An alternative explanation, involving social norms, can be found in López-Calva (1999). Basu (2001) suggests that children's labor force participation is not independent of the balance of power in the household.

That fertility is in essence endogenous and that recognizing it as such may have important consequences on the understanding of economic phenomena did not seem evident until the work of Becker & Lewis (1973). The latter paper opened up a very prolific new literature whose contributions we cannot give a very good account in a few lines. Barro & Becker (1989) and Becker, Murphy, & Tamura (1990) relate fertility decisions and economic growth. The link between fertility, child labor and growth was first analyzed by Moe (1998) and Dessy (2000). Both study the growth effects of child labor and the tradeoff between fertility and education. They identify conditions for a poverty trap.

Technology adoption and the prevalence of low-productivity, traditional technologies in poor countries has always puzzled economists. These questions are directly linked to the more fundamental question of why some countries stay poor while others have become rich. Many authors have tried to provide answers to these questions. Rosenstein-Rodan (1943) and Murphy, Shleifer, & Vishny (1989) suggest that expectations play a role in determining whether a country's industrialization will take-off. They illustrate cases of self-fulfilling prophecies. Parente & Prescott (1994, 1999) show that an explanation for the diverging fate of countries may lie in the prevalence of suboptimal institutional arrangements such as monopoly rights. Howitt (2000) puts part of the blame on obstacles to R&D investments: countries in which the conditions for R&D are unfavorable will not benefit from international R&D spillovers and will stagnate, that is fall further and further behind the world's growing technological frontier. Matsuyama (1996) and Dessy & Pallage (2002)

provide conditions under which the set of equilibria may be different across countries, in which case countries may end up in different development states not because of differing expectations, but because of the inexistence of a common equilibrium.

The rest of the paper is organized as follows. Section 2 builds the model and highlights the strategic complementarity of parents and entrepreneurs' decisions. Section 3 identifies Nash equilibria of the game. Section 4 discusses policy implications of our results and concludes.

2 The Model

We develop a simple model of endogenous fertility and new technology adoption for which parental decision on child's time use is a major feature. The economy lasts for two periods. In the first period, there is a continuum of homogeneous parents of total mass normalized at unity. Each parent has one period left to live, is endowed with one unit of labor outside his leisure time. Initially, all parents are unskilled. In the beginning of the first period, all parents must decide on the number of children they wish to have and on the allocation of child's time between schooling and work.

As is standard in the literature on endogenous fertility (see for example, Barro and Becker, 1989; Moe, 1998; and Dessy, 2000), parents are altruistic towards their offspring, and are lifetime-utility-maximizers, with expected cardinal utility function over household consumption c , number of children n and children's labor income when adult I' . Without loss of generality, we assume that this utility function is logarithmic:

$$U(c, n, I') = \ln(c) + \rho \ln(n) + \beta E[\ln(I')], \quad \rho > 0; \quad 0 < \beta < 1 \quad (1)$$

where β is the usual intergenerational time-discounting factor measuring the degree of parental altruism, ρ is a the utility weight a parent puts on the size of his offspring, and E denotes the expectation operator conditional on current period information.

Children make no decision in this environment. A typical child is endowed with one unit of time. The child's time endowment can be allocated to two possible occupations: schooling, in which case the child accumulates human capital which may enable him to work as a skilled worker when adult; or work, in which case the child earns a labor income which he totally contributes to the household. For simplicity, we assume that parents do not differentiate between their children.

What they choose for one, they choose for all.

We denote by e children's time allocated to schooling. Without loss of generality, we assume that a child either goes to school full-time or work: e is therefore restricted to the set $\{0, 1\}$. The parent-children relationship is summarized by the parent's fertility and child-rearing strategy. This strategy simply specifies the number of children n a parent chooses to raise and the fraction of time e each child is to spend receiving an education. As is standard in the literature on fertility and child's schooling (e.g. Barro and Becker, 1989; Moe, 1998; and Dessy, 2000), the decision on child's quality is made jointly with the decision on the quantity of children and on household consumption.

Child rearing entails a cost which we assume linear in the number of children: qn . Denoting by w_a and w_c the income from adult labor and child labor respectively, we have the following budget constraint for a parent:

$$c \leq w_a + n(1 - e)w_c - qn$$

2.1 Production

On the production side, there is a continuum 1 of two-period-lived identical entrepreneurs who produce a homogeneous consumption good according to either a skill-intensive technology or a cottage-industry technology which is intensive in unskilled labor. We take the consumption good as the *numeraire*. Following Acemoglu (1994), workers and entrepreneurs are randomly matched one-to-one so that no productive resources are left idle in this economy. The surplus generated by a match, which we denote as Y , is divided between the worker and the entrepreneur, with a fraction $\alpha \in (0, 1)$ going to the worker, while the remainder, $1 - \alpha$, goes to the entrepreneur.

Assume that in the initial period (period 0), all firms are operating the cottage-industry technology. The total surplus generated by a match between a worker and a firm operating the cottage-industry technology is $Y_0 = A$. In the first period, the representative firm must decide whether or not to devote an exogenous fraction, γ , of its share of period 0 surplus to the acquisition of a skill-intensive technology which it will operate in period 1. This decision is made as part of a strategy to maximize the value of the firm which we will specify further below.

Let x denote a typical element of the representative firm's strategy set, $X = \{0, 1\}$. When $x = 0$

(respectively, $x = 1$), the representative firm's strategy is not to invest (respectively, invest) in skill-biased technology. If the representative entrepreneur chooses $x = 0$, the period 1 surplus from a match will be $Y_1 = A$. On the other hand, if he plays strategy $x = 1$, the next period surplus will be $Y_1 = B > A$ if he is matched with a skilled worker in period 1; it will equal A , however, if he is matched with an unskilled worker. In other words, assuming a time-discounting factor $\delta \in (0, 1)$, the value of the firm when the entrepreneur plays strategy x is given by:

$$V(x; e) = \begin{cases} (1 - \alpha)(1 + \delta)A & \text{if } x = 0 \\ (1 - \alpha)A(1 - \gamma + \delta) & \text{if } x = 1 \text{ and } e = 0 \\ (1 - \alpha)[A(1 - \gamma) + \delta B] & \text{if } x = 1 \text{ and } e = 1 \end{cases} \quad (2)$$

Following Glomm (1997) and Dessy & Pallage (2001a), we assume that child labor is an informal sector phenomenon. This corresponds to a situation in which children take employment in the informal sector, as street vendors, shoe polishers, luggage carriers, etc. These activities do not require specific skills, nor contribute to skill formation (see, Swaminathan, 1998). Technology in that sector is normalized such that one unit of labor yields one unit of the unique consumption good. Income from child labor sources is the child's production $w_c = 1$. To ensure that adults have no incentive to work in that sector we choose α and A such that $w_a = \alpha A > 1$.

We assume that parents and entrepreneurs solve their respective problem simultaneously. This assumption is consistent with a body of empirical evidence that technology adoption in developing countries is far from instantaneous. In fact, if schooling and child rearing take time and effort, so it does to adapt the modern technology to local environments (see, e.g., Abramovitz, 1986; Bell and Pavitt, 1993; Pack, 1993). In such case, investment in education or investment in modern technology are strategic complements and the choices are best analyzed in a game-theoretic setup.

2.2 The Representative Parent's problem

Given our description of the labor market, the budget constraint of a parent can be rewritten as:

$$c \leq \alpha A + (1 - e)n - qn, \quad (3)$$

The representative parent chooses c , n , and e so as to maximize (1) subject to the above constraint. Given the form of the utility function, the budget constraint will be binding in the optimum. There-

fore the representative parent's problem reduces to:

$$\max_{\langle e, n \rangle} \{ \ln(\alpha A + (1 - e)n - qn) + \rho \ln(n) + \beta E(\ln[I'(e; x)]) \}, \quad (4)$$

with:

$$I'(e; x) = \begin{cases} \alpha A & \text{if } x = 0 \text{ or } e = 0 \\ \alpha B & \text{if } x = 1 \text{ and } e = 1 \end{cases} \quad (5)$$

To solve the representative parent's problem, we assume that the representative parent chooses first e then fertility n . Therefore, by backward induction this parent first solves (4) given e . A pure strategy for a parent is a pair of decisions $s = [e, n(e)]$. The first order condition for an interior solution to this problem is:

$$\frac{-q + 1 - e}{\alpha A + (1 - e)n - qn} + \frac{\rho}{n} = 0 \quad (6)$$

This first order condition is satisfied by the value of n that equates the marginal cost (in terms of utility) of reducing household consumption in order to enjoy an additional child to the marginal utility gain of having an additional child. Note that for this first order condition to make sense, it must be that $q > 1$, i.e. a child by working full-time brings back home an income smaller than the unit cost of child rearing. Were this condition not satisfied parents would all want an infinite number of children.

Proposition 1 (Quantity-quality tradeoff) *Under the condition that there is a net cost to having children ($q > 1$), parents planning to educate all their children will always have fewer children.*

Proof. From (6), we can solve for the optimal number of children for each possible choice of education e :

$$n^*(e = 0) = \frac{\alpha A \rho}{(q - 1)(1 + \rho)} \quad \text{and} \quad n^*(e = 1) = \frac{\alpha A \rho}{q(1 + \rho)} \quad (7)$$

Since $q > 1$, $n^*(e = 0) > n^*(e = 1)$, which completes the proof. ■

For ease of notations, we define $\bar{n} = n^*(e = 0)$ and $\underline{n} = n^*(e = 1)$. The pure-strategy set of parents essentially reduces to two strategies $s_0 = (e = 0, \bar{n})$ and $s_1 = (e = 1, \underline{n})$. Proposition

1 is a replica of the standard quantity-quality tradeoff well-known in the literature on endogenous fertility and child's schooling (e.g. Barro and Becker, 1989; Becker, Murphy and Tamura, 1990; Dessy, 2000). It states that there is a negative association between number and quality of children in the household.

For each schooling choice, we can characterize the optimal household consumption. Interestingly, this consumption level turns out to be the same regardless of the education decision: the representative parent adjusts the number of children to remain at the same level of consumption.

$$c_{s_0}^* = c_{s_1}^* = \frac{\alpha A}{1 + \rho} = c^* \quad (8)$$

Given x , the choice of strategy of the representative entrepreneur, we can write the value for a parent of playing strategies s_0 and s_1 as respectively:

$$W(s_0; x) = \ln(c^*) + \rho \ln\left[\frac{\alpha A \rho}{(q-1)(1+\rho)}\right] + \beta \ln[\alpha A] \quad (9)$$

$$W(s_1; x) = \ln(c^*) + \rho \ln\left[\frac{\alpha A \rho}{q(1+\rho)}\right] + \beta \ln[\alpha Bx + \alpha A(1-x)] \quad (10)$$

Subtracting (9) from (10) we obtain the net value for a parent of choosing education and low fertility (that is s_1) as a function of x :

$$\nu(x) = \rho \ln\left[\frac{q-1}{q}\right] + \beta \ln\left[\frac{Bx + A(1-x)}{A}\right] \quad (11)$$

2.3 The representative entrepreneur's problem

The representative entrepreneur does not care much about fertility choices of parents, but he does care a lot about education decisions. Given the representative parent's choice of investment in his children's education, e , if the representative entrepreneur chooses to devote a strictly positive fraction γ of his period 0 surplus to the acquisition of a skill-intensive technology, the value of the firm will be given by:

$$V(1; e) = (1 - \alpha) (1 - \gamma) A + (1 - \alpha) \delta [eB + (1 - e) A]. \quad (12)$$

If, however, the representative entrepreneur does not invest in period 0 to set up the modern technology, the value of the firm will be given by:

$$V(0; e) = (1 - \alpha) (1 + \delta) A. \quad (13)$$

Observe from (12) and (13) that if the entrepreneur invests a fraction γ of his first-period surplus in order to adopt the skill-intensive technology for the last period, and there are no skilled workers comes that period ($e = 0$), he will incur a loss of $(1 - \alpha)\gamma A$. Therefore in planning his investment strategy, the representative firm must take into account parents' willingness to invest in child quality.

The problem of the representative entrepreneur boils down to choosing x to maximize:

$$V(x; e) = (1 - \alpha) (1 + \delta) A + (1 - \alpha)x [e\delta (B - A) - \gamma A]. \quad (14)$$

3 Nash equilibria

Simultaneously solving the respective problems of the representative parent and the representative entrepreneur, we identify at most two Nash equilibria in pure strategies and one in mixed strategies.² The first equilibrium, whose existence is independent of parameter values, is characterized by high fertility, intensive use of child labor and no investment in skill-biased technologies. The second equilibrium in pure strategies, whose existence depends on the relative cost of technology adoption by firms and the wage premium of skilled labor, is characterized by low fertility, no child labor and modern technology adoption.

Proposition 2 (Nash equilibria) *If (i) $\gamma \leq \delta(B - A)/A$ and (ii) $B/A \geq (\frac{q}{q-1})^{\frac{\rho}{\beta}}$, then there exist two Nash equilibria in pure strategies and one in mixed strategies. The first pure strategy Nash equilibrium has high fertility and no investment $[s_0, x = 0]$. The second is Pareto superior and has low fertility and both types of investments $[s_1, x = 1]$. The mixed strategy Nash equilibrium implies investment by entrepreneurs with probability $\sigma = \frac{\rho}{\beta} \frac{\ln[q/(q-1)]}{\ln[B/A]}$ and parents choose education and low fertility with probability $\theta = \frac{A\gamma}{\delta(B-A)}$. If either (i) or (ii) is not satisfied, only the first Nash equilibrium survives.*

²By working throughout with representative players, we ignore any strategic behavior between parents or between entrepreneurs. We do so for ease of presentation.

Proof. From (12) and (13), one can see that entrepreneurs' best response to $e = 0$ is $x = 0$, the best response to which implies $e = 0$ as the parental net value (11) from choosing education and low fertility is always negative in this case. This establishes existence of the first Nash equilibrium. The entrepreneurs' best response to $e = 1$ implies $x = 1$ only if (12) dominates (13), which requires condition (i) in Proposition 2. The parents' best response to $x = 1$ in turn implies that the net value ν from choosing s_1 is positive. From (11), we can see that condition (ii) is necessary for this to be the case. Therefore $[s_1, x = 1]$ is a Nash equilibrium only if (i) and (ii) hold simultaneously. It is straightforward to verify that under (i) and (ii) the second pure strategy Nash equilibrium Pareto dominates the first. To find the probabilities underlying the mixed strategy Nash equilibrium, we use the fact that no player would use a mixed strategy unless he is indifferent between his pure strategies. It is immediate that under conditions (i) and (ii) the suggested pair (σ, θ) satisfies the elementary laws of probabilities. ■

The first Nash equilibrium is clearly a poverty trap. The mixed strategy Nash equilibrium, while theoretically interesting is unstable. Any small perturbation in the beliefs of players breaks their indifference between their pure strategies and makes them move away from that equilibrium. The second pure strategy Nash equilibrium requires that the cost of technology adoption be sufficiently low and the wage premium from skilled labor be sufficiently high. Arguably, these conditions are more easily met in a rich country. Notwithstanding the above, if the status quo is the 'bad Nash equilibrium,' deviations from that equilibrium by a single player puts all the cost of deviating on that player's shoulders. Deviation from the status quo is therefore a very risky business. If parents, who have not seen much modern technology in the past, do not believe strongly enough that entrepreneurs are investing in such skilled biased technologies, it is always a best response to choose high fertility and child labor. By the same token, if entrepreneurs, used to a poor level of educational attainment, do not believe strongly enough that parents are indeed choosing education for their children, their best response is the no-investment status quo. Moreover, it is sufficient that entrepreneurs believe that parents believe that they will not invest, for no investment to be an optimal choice of entrepreneurs. All these reasons lead us to believe that the 'bad Nash equilibrium' is very likely in the poorest countries. The inability of beliefs to coordinate makes it impossible to attain the 'good equilibrium.'

4 Policy analysis

If economic and social conditions are such that there is only one Nash equilibrium in this game, that is the ‘bad’ one, policy should be devoted to first establishing the conditions for the existence of the ‘good’ equilibrium. On the one hand, if the cost of technology adoption is prohibitive with respect to its future gain (condition (i) in Proposition 2 is violated), chances are that removing barriers to entrepreneurship and barriers to formalization, would be a welcome policy. Such barriers could be corruption, formalization fees, administrative hassle or lack of public infrastructure. Our parameter γ partly captures all these elements. Subsidizing technology adoption is also a policy option which would work in the same direction.

On the other hand, if parents never find it worthwhile to choose low fertility combined with education for their children, it might be for various reasons: 1) too low a discount factor β , 2) too high a utility weight on fertility ρ , 3) too low a wage premium for skilled labor B/A , and 4) too small the child rearing cost q . Policy makers might have a hard time imagining policies that would target the first three elements above. Yet the fourth one suggests something about the opportunity set of women. If child rearing costs are too low from the perspective of Proposition 2, that might be because women have little access to education and to labor markets. Policies that would help decrease discrimination against women would provide the ground for condition (ii) to be satisfied.

Once both conditions (i) and (ii) in Proposition 2 are satisfied, policies should aim at helping expectations coordinate. Among such policies, we find child labor bans, compulsory education, family planning and subsidies to firms adopting modern technologies. Child labor bans in this model would serve as a signal to firms that educated adults will be available in the future. They would also serve as a signal to parents that firms have received that signal. In that sense, bans are self-enforcing. Once promulgated, they are redundant, as an equilibrium without child labor is immediately selected. Fertility decisions are adjusted consistently with this new equilibrium. Compulsory schooling laws play a similar role in signalling to players what others are likely to do. Family planning, though highly controversial, would act in the same way. In this model, it would never have to be enforced as the Pareto superior equilibrium would be selected by the players. Alternatively, if policy makers are reluctant to use legislative intervention, they could use budgetary policy and subsidize technology adoption. Although more costly than other policies, such subsidy would also serve as a signal to parents that entrepreneurs are likely to invest. The

problem with subsidizing entrepreneurs is that it can be viewed by other countries as an unfair trade practice (e.g. Canada and Brazil currently have a trade dispute over subsidies paid by the Brazilian government to the Brazilian Jet constructor Embraer). Such disputes can seriously alter the social benefits of the subsidy.

Our paper is quite simple. We believe that it provides one explanation about why rich and poor countries differ in their fertility choices, diffusion of modern technologies and size of child labor markets. The policy analysis has raised a particularly interesting issue which we find worthy of further investigation: the determinants of the cost of child rearing are not well-known. Our intuition suggests that a better understanding of this cost may lead to development policies that could have a significant impact.

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